Survival and Health Care Use After Feeding Tube Placement in Children With Neurologic Impairment

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abstract

BACKGROUND AND OBJECTIVES: Children with neurologic impairment (NI) often undergo feeding tube placement for undernutrition or aspiration. We evaluated survival and acute health care use after tube placement in this population.

METHODS: This is a population-based exposure-crossover study for which we use linked administrative data from Ontario, Canada. We identified children aged 13 months to 17 years with a diagnosis of NI undergoing primary gastrostomy or gastrojejunostomy tube placement between 1993 and 2015. We determined survival time from procedure until date of death or last clinical encounter and calculated mean weekly rates of unplanned hospital days overall and for reflux-related diagnoses, emergency department visits, and outpatient visits. Rate ratios were estimated from negative binomial generalized estimating equation models adjusting for time and age.

RESULTS: Two-year survival after feeding tube placement was 87.4% (95% confidence interval [CI]: 85.2%–89.4%) and 5-year survival was 75.8% (95% CI: 72.8%–78.4%). The adjusted rate ratio comparing weekly rates of unplanned hospital days during the 2 years after versus before tube placement was 0.92 (95% CI: 0.57–1.48). Similarly, rates of reflux-related hospital days, emergency department visits, and outpatient visits were unchanged. Unplanned hospital days were stable within subgroups, although rates across subgroups varied.

CONCLUSIONS: Mortality is high among children with NI after feeding tube placement. However, the stability of health care use before and after the procedure suggests that the high mortality may reflect underlying fragility rather than increased risk from nonoral feeding. Further research to inform risk stratification and prognostic accuracy is needed.

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WHAT'S KNOWN ON THIS SUBJECT: Feeding tubes are common among children with neurologic impairment and are associated with clinical benefits and potential harms. Population-based evidence on survival and health care use after feeding tube placement is lacking.

WHAT THIS STUDY ADDS: Two- and 5-year mortality rates after feeding tube placement for children with neurologic impairment are high. Rates of acute health care use across settings and within subgroups are stable during 2 years after feeding tube placement compared with before.

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In pediatrics, neurologic impairment (NI) refers to a broad group of diagnoses, including cerebral palsy and specific genetic or metabolic conditions, which cause similar problems in cognitive and physical function.[1] Children with NI have high health care costs; authors of a 2012 study in Ontario found that <1% of children accrued one-third of total child health spending, and children with NI were the largest subgroup (28%) within the high-cost cohort.[2] In an American study of children in structured programs for children with medical complexity (57% with NI), nearly half of admissions were for surgical interventions, most commonly (19%) for gastroenterological or feeding-associated procedures.[3] In this population, feeding tubes are typically placed to improve nutrition or to reduce oral aspiration from swallowing dysfunction.[4]

Although feeding tubes are common (in 2 large studies, ~10% of children with NI had a feeding tube[2,5]), outcomes, particularly long-term ones, are not well described.[6] Authors of a systematic review of outcomes after gastrostomy among children with cerebral palsy identified 11 studies, which were mostly case series; none of the studies included >60 patients.[7] Population-based long-term mortality after feeding tube placement is unknown. Effects of feeding tubes on gastroesophageal reflux, a noted source of morbidity[8] and potential contributor to mortality via aspiration pneumonia[9,10] in this population, are mixed. It is suggested in some studies that feeding tubes worsen reflux[11] leading to increased pneumonias,[12] and others describe decreased hospitalizations for pneumonias post–feeding tube placement.[13] Optimal reflux management is unclear[14]; some children undergo prophylactic antireflux surgery (Nissen fundoplication) with gastrostomy tube (GT) placement, whereas others undergo gastrojejunostomy tube (GJT) placement.[15] Authors of several studies have evaluated hospitalization rates for reflux-associated diagnoses after antireflux procedures (surgery and GJTs)[5,14,16–18]; less has been described about broader categories of acute health care use. Our goal of this study is to describe survival and acute health care use, including changes in rates of unplanned hospital days, hospital days for reflux-related diagnoses, emergency department visits, and outpatient visits, after feeding tube placement among children with NI.

METHODS

Study Design and Setting

In this population-based cohort study, we used health administrative data from Ontario, a province with a population of ~13 million people. To quantify changes in acute health care use before and after tube placement, we used a self-matching methodology, the exposure-crossover design.[19]

Study Data

The health care system in Ontario provides government insurance that includes free access to inpatient, emergency department, and outpatient care for all residents. By using validated data sources linked by coded patient identifiers,[20] children can be managed over time. For this study, we accessed demographic information, vital statistics, hospitalization data, outpatient procedure records, emergency department visit data, physician billing for outpatient and emergency department visits, aggregated neighborhood census data, a database linking maternal and infant records, immigration data, and a physician specialty database (Supplemental Information). These data were analyzed at the Institute for Clinical Evaluative Sciences (ICES), which is legislatively permitted to use these data sources without individual consent for health system research, provided strict privacy guidelines are followed. We obtained research ethics approval from the Hospital for Sick Children and administrative approval from the University of Toronto.

Study Population

We identified all children in Ontario undergoing primary feeding tube placement (Supplemental Table 9) between April 1, 1993, and March 3, 2015, with data collection through March 31, 2016. To be included, the feeding tube had to be placed at least 1 year plus 4 weeks (56 weeks) after the newborn hospitalization discharge and 56 weeks before the child's 18th birthday. Additionally, children had to have a diagnosis code consistent with NI on a hospital record before or at the time of tube placement. We defined NI as a neurologic diagnosis on an established list of pediatric complex chronic conditions (CCCs)[21,22] or a nonneurologic CCC that was also included on an extensive list of diagnoses associated with pediatric NI (Supplemental Table 10).[1] We excluded children born before April 1, 1992, children without a valid encoded identifier to allow data set linkage, and those not continuously eligible for the Ontario Health Insurance Plan for 56 weeks before and after tube placement. Because of clinical differences between GTs and GJTs, children with ambiguous codes for tube type were also excluded. We excluded children who died within 28 days of feeding tube placement from the main study cohort. However, we included their data in the survival analysis for completeness.

Exposure and Time Intervals

Time 0 was the date of feeding tube placement. Each child was managed forward for up to 5 years and backward for up to 2 years. For the exposure-crossover analysis,

we limited comparison with the 2 years before (baseline interval) and after (subsequent interval) tube placement, excluding the 4 weeks immediately before and after tube placement (induction interval) because of fluctuating risk of hospitalization from unsafe preoperative oral feeding and short-term postoperative complications. For model stability, children, except children who died during the subsequent interval, required a minimum of 1 year plus 4 weeks of data before and after tube placement.

Outcomes

We calculated days of survival from tube placement until date of death. Data from surviving children with <5 years of follow-up were censored on the date of their last clinical encounter. Feeding tube revision was defined as a second tube placement procedure code after the initial placement. Antireflux surgeries occurring >1 week after the primary tube were considered subsequent. Procedure codes are listed in the Supplemental Information.

For health care use, we divided time into 1-week segments before and after time 0 and counted outcomes during each week. Outcomes included unplanned hospitalization days, unplanned hospital days with primary diagnosis codes related to reflux[18] (Supplemental Information), emergency department visits without admission, and outpatient visits.

Covariates

Covariates were defined at the time of tube placement. Neighborhood income quintile, adjusted for community and household size, was determined for areas of 400 to 700 inhabitants by using postal code and census data and was used as a proxy for socioeconomic status. Rurality was determined with an Ontario-specific score by using postal code. Immigration status was determined through immigration records for children or mothers in the Immigration, Refugees, and Citizenship Canada Permanent Resident Database. We classified tube type using physician billing and procedure codes. Children with presurgical hospitalizations >2 days had "inpatient" procedures. With reference to a published algorithm,[23] 3 pediatricians (K.E.N., A.G., and E.C.) with relevant clinical expertise and experience validating *International Classification of Diseases* codes for research defined NI diagnosis codes as "progressive" if significant decline or death would be expected during childhood. All hospital records before tube placement were evaluated for CCC diagnosis codes. Presence of other medical technology (tracheostomy, cerebrospinal fluid shunt, evacuation tube, renal or cardiac support, infusion pump) was determined by inclusion of diagnosis or procedure codes on a hospital record without a subsequent removal code before tube placement. Antireflux procedures included both GJTs and antireflux surgery (Nissen fundoplication); procedure codes for antireflux surgery within 1 week of tube placement were considered concomitant. Provider type was determined by using an Ontario-specific algorithm. Additional covariate details are described in the Supplemental Information.

Descriptive Analyses

We fit a Kaplan-Meier survival curve for the cohort from the date of tube placement, stratifying by antireflux procedure status. We created bamboo plots,[19] which are specific to the exposure-crossover design and depict rates over time, revealing weekly per-child rates of the health care use outcomes over 7 years (2 years before and 5 years after tube placement).

Primary Analysis

For the exposure-crossover analysis, we compared acute health care use during the 2 years before and after feeding tube placement, excluding the 8-week induction interval adjacent to the procedure. When underlying time trends were visible on the bamboo plot, we used a negative binomial generalized estimating equation (GEE) with a compound symmetry covariance structure to calculate a rate ratio (RR) comparing the mean rates in the subsequent interval to the baseline interval using the child's proportion of weeks at risk during the interval as an offset. To account for time trends, we adjusted estimates for the number of weeks from the beginning of follow-up. We further adjusted for age at intervention.

To evaluate for survivor bias and era effect, we performed prespecified sensitivity analyses excluding children who died during the subsequent interval and stratifying by era (1993–2000, 2001–2005, 2006–2010, and 2011–2015). To assess robustness, we ran models in which outliers were excluded, and we tested longer and shorter induction intervals. Because an emergency department–specific database debuted in 2002, we performed a sensitivity analysis excluding pre-2002 data.

For the primary outcome of unplanned hospital days, we performed prespecified subgroup analyses for children older and younger than 4 years of age at tube placement,[24] with and without progressive NI, with and without antireflux procedures, and children who were and were not inpatients at the time of feeding tube placement. To evaluate for variation in patterns of secondary outcomes between children with and without antireflux procedures, we created stratified bamboo graphs.

Secondary Analysis

As an exploratory post hoc analysis to quantify the relative effects of membership in the subgroups (older

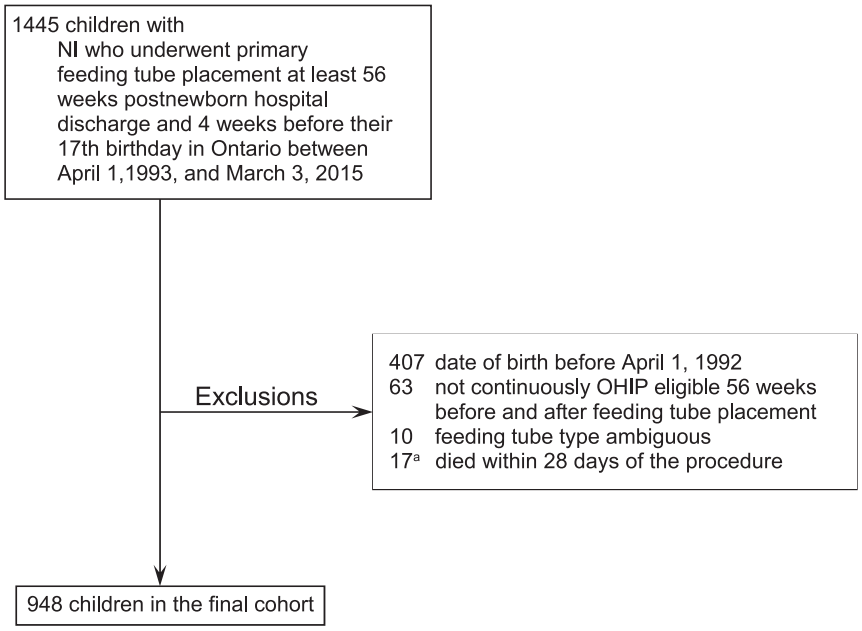

FIGURE 1

Cohort creation. [a] Data from the 17 children who died within 28 days were included in the survival analysis. OHIP, Ontario Health Insurance Plan.

and younger than 4 years of age,[24] with and without progressive NI, with and without antireflux procedures, and children with inpatient and outpatient tube placement), we fit a negative binomial multilevel growth curve model on days of hospitalization per week during the subsequent interval. The level 1 components of the model included random slopes and random intercepts for each child. The level 2 components included all covariates, which were defined at time 0 and treated as time invariant. For covariates with >5% of missing values, we assigned a category as missing; otherwise, we performed complete-case analysis. All analyses were performed in SAS version 7.1 (SAS Institute, Inc, Cary, NC); all testing was 2 sided, and *P* values <.05 were considered significant.

RESULTS

Demographics

We identified 948 children with NI who underwent primary feeding tube placement in 24 Ontario hospitals between 1993 and 2015 (Fig 1). Median follow-up was the maximum 5 years (interquartile range [IQR]: 3.6–5); data from 12 children (1.3%) and 160 children (16.9%) were censored within 2 and 5 years, respectively. Cohort characteristics are depicted in Table 1; children with and without antireflux procedures are similar, except in the proportion undergoing antireflux procedures over time and patterns of diagnoses. Supplemental Tables 4 and 5 reveal the most common diagnoses associated with each NI and CCC category.

Survival, Tube Revision, and Subsequent Antireflux Surgery

Figure 2 is a 5-year Kaplan-Meier survival curve from the date of tube placement; for completeness, it includes data from 17 children who were excluded from the main study cohort because of death within 4 weeks of tube placement. Including the 17 early deaths, 121 children died within the first 2 years, and 222 died within 5 years of tube placement. Survival curves stratified by antireflux procedure status did not differ over the study period (the log-rank test χ^2 was 0.67; $P = .41$), so results are aggregate. One-year survival was 91.3% (95% confidence interval [CI]: 89.3%–92.9%), 2-year survival was 87.4% (95% CI: 85.2%–89.4%), and 5-year survival was 75.8% (95% CI: 72.8%–78.4%).

After initial feeding tube placement, 132 children (13.9%) required feeding tube revision within 5 years, with a median time to revision of 6.4 weeks (IQR: 0.6–55.1) and median age of 4.3 years (IQR: 2.4–7.1). Fifty children (5.3%) underwent subsequent antireflux surgery at a median time of 66.8 weeks (IQR: 25.6–119.9) after tube placement and median age of 4.3 years (IQR: 3.0–6.2).

Unplanned Hospital Days (Primary Outcome)

The median number of admissions during the baseline interval was 2 (IQR: 0–3) with a median length of stay (LOS) of 4 days (IQR: 2–9). For the 2-year subsequent interval, the median number of admissions was 1 (IQR: 0–3) with a median LOS of 4 days (IQR: 2–8). The most common primary admission diagnoses are listed in Supplemental Table 6. Unplanned hospital days per child-week are shown in Fig 3. Neither baseline nor subsequent intervals are stationary. The adjusted RR of 0.92 (95% CI: 0.57–1.48) reveals that weekly rates of unplanned hospital days were stable before and after the procedure (Table 2).

Sensitivity Analyses of Primary Outcome

We performed sensitivity analyses to evaluate for survivor bias and for model robustness (Supplemental Table 7). Restricting the cohort to survivors resulted in an RR of 0.64 (95% CI: 0.44–0.94), suggesting that children who died used more health care in the subsequent interval than survivors. However, we kept children who died in the final cohort because

TABLE 1 Cohort Characteristics

	Full Cohort (*N* = 948)	GT Only (*N* = 544)	With Antireflux Procedure (Nissen or GJT) (*N* = 404)
Year of tube placement, *n* (%)			
1993–2000	165 (17.4)	75 (13.8)	90 (22.3)
2001–2005	275 (29.0)	118 (21.7)	157 (38.9)
2006–2010	277 (29.2)	151 (27.8)	126 (31.2)
2011–2015	231 (24.4)	200 (36.8)	31 (7.7)
Age at insertion, y, *n* (%)			
1–2	366 (38.6)	201 (36.9)	165 (40.8)
3–5	235 (24.8)	129 (23.7)	106 (26.2)
>6	347 (36.6)	214 (39.3)	133 (32.9)
Sex, *n* (%)			
Female	425 (44.8)	245 (45.0)	180 (44.6)
Neighborhood income quintile, *n* (%)			
1[a]	218 (23.0)	133 (24.4)	85 (21.0)
2	194 (20.5)	109 (20.0)	85 (21.0)
3	184 (19.4)	94 (17.3)	90 (22.3)
4	185 (19.5)	107 (19.7)	78 (19.3)
5 (highest)	167 (17.6)	101 (18.6)	66 (16.3)
Rural residence, *n* (%)			
Yes[b]	134 (14.1)	84 (15.4)	50 (12.4)
Immigration status, *n* (%)			
Nonrefugee, new immigrant	22 (2.3)	16 (2.9)	6 (1.5)
Nonrefugee, not new immigrant	283 (29.9)	163 (30.0)	120 (29.7)
Not immigrant	609 (64.2)	347 (63.8)	262 (64.9)
Refugee	34 (3.6)	18 (3.3)	16 (4.0)
Birth wt, g, *n* (%)			
<1500	134 (14.1)	67 (12.3)	67 (16.6)
1500–2499	119 (12.6)	68 (12.5)	51 (12.6)
≥2500	561 (59.2)	327 (60.1)	234 (57.9)
Missing	134 (14.1)	82 (15.1)	52 (12.9)
NI category,[c] *n* (%)			
Cerebral palsy	467 (49.3)	326 (30.7)	141 (13.3)
Central nervous system degeneration and diseases	189 (19.9)	128 (12.0)	61 (5.7)
Brain and spinal cord malformations	178 (18.8)	119 (11.2)	59 (5.6)
Muscular dystrophy, myopathies, and movement disorders	70 (7.4)	49 (4.6)	21 (2.0)
Epilepsy	55 (5.8)	49 (4.6)	6 (0.6)
Other disorders of the central nervous system	45 (4.7)	28 (2.6)	17 (1.6)
Genetic and metabolic	37 (3.9)	28 (2.6)	9 (0.8)
Malignancy	22 (2.3)	9 (0.8)	13 (1.2)
Progressive NI, *n* (%)			
Yes	156 (16.5)	86 (15.8)	70 (17.3)
No. other CCCs,[c] *n* (%)			
None	390 (41.1)	216 (39.7)	174 (43.1)
1	384 (40.5)	232 (42.6)	152 (37.6)
≥2	174 (18.4)	96 (17.6)	78 (19.3)
CCC category,[c] *n* (%)			
Premature and neonatal	220 (23.2)	164 (30.1)	56 (13.9)
Other congenital or genetic defect	144 (15.2)	107 (19.7)	37 (9.2)
Cardiovascular	104 (11.0)	67 (12.3)	37 (9.2)
Metabolic	99 (10.4)	66 (12.1)	33 (8.2)
Respiratory	62 (6.5)	46 (8.5)	16 (4)
Hematologic or immunologic	44 (4.6)	31 (5.7)	13 (3.2)
Malignancy	42 (4.4)	23 (4.2)	19 (4.7)
Gastrointestinal	39 (4.1)	25 (4.6)	14 (3.5)
Renal and urologic	37 (3.9)	21 (3.9)	16 (4)
Miscellaneous, not elsewhere classified	<6 (<0.6)	—	—
Other medical technology, *n* (%)			
Present	157 (16.6)	80 (14.7)	77 (19.1)
Antireflux procedure, *n* (%)			
None	544 (57.4)	544 (100)	—
GT	265 (28.0)	—	265 (65.6)
Antireflux surgery (before or with tube placement)	113 (11.9)	—	113 (28.0)

TABLE 1 Continued

	Full Cohort ($N = 948$)	GT Only ($N = 544$)	With Antireflux Procedure (Nissen or GJT) ($N = 404$)
Both	26 (2.7)	—	26 (6.4)
Specialty of primary doctor, *n* (%)			
Pediatrician	441 (46.5)	274 (50.4)	167 (41.3)
Family doctor or general practitioner	<6 (<0.6)	<6 (<1.1)	<6 (<1.5)
Other	>13 (>1.4)	>6 (>1.1)	>6 (>1.5)
None	488 (51.5)	259 (47.6)	229 (56.7)

—, not applicable.

[a] Census data are suppressed for areas with high residential instability, which are typically low income, so missing data ($n = 9$) are combined with the lowest quintile.

[b] Because most Ontario residents live in urban areas, those missing data ($n < 6$) were combined with nonrural residency.

[c] May be in multiple categories.

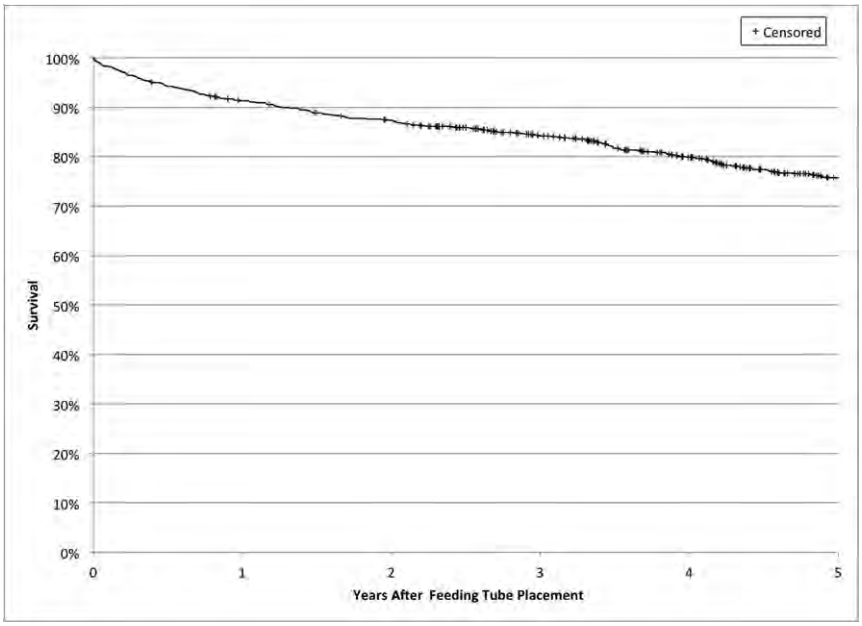

FIGURE 2
Kaplan-Meier survival curve. Time 0 is the date of initial feeding tube placement.

it is impossible to prospectively predict survivorship. Hospitalization rates remained relatively stable across eras. Model robustness findings were similar to the primary analysis. To evaluate visible time trends, we added analyses doubling and tripling the induction interval; otherwise, all analyses were prespecified.

Reflux-Related Hospital Days, Emergency Department Visits Without Admission, and Outpatient Visits

There were 526 reflux-related hospitalizations in the baseline interval (22.0% of total baseline hospitalizations) with a median LOS of 4 days (IQR: 2–8). In the subsequent interval, there were 694 reflux-related hospitalizations (31.1% of total) with a median LOS of 5 days (IQR: 2–9). There were 2376 emergency department visits without admission and 13 923 outpatient visits in the baseline interval compared with 2063 emergency department visits and 13 727 outpatient visits in the subsequent interval. The most common diagnoses for emergency department visits without admission are shown in Supplemental Table 8. The bamboo plots and adjusted RRs for reflux-related hospital days, outpatient appointments, and emergency department visits are shown in Supplemental Fig 4. The RRs for all secondary outcomes revealed stability of rates after the procedure. Bamboo plots stratified by antireflux procedure (Supplemental Fig 5) and outpatient visits stratified by provider (primary versus subspecialist) revealed the same patterns as the combined analysis. The analysis, including emergency department data after 2002, was similar to the full data set (RR 1.22; 95% CI: 0.96–1.57).

Subgroup Analyses of Unplanned Hospital Days

We performed 4 prespecified analyses of clinically important subgroups on the primary outcome (Table 2). Supplemental Figs 6 and 7 are bamboo plots with adjusted RRs for children older and younger than 4 years of age at tube placement, with and without progressive NI, with and without antireflux procedures, and children who were and were not inpatients at the time of feeding tube placement. Although no subgroup revealed a change in rates after tube placement compared with before, several subgroups had visibly higher rates of weekly unplanned hospital days after tube placement compared with their counterpart (eg, children with inpatient versus outpatient procedures).

Secondary Analysis

To quantify variation in rates across subgroups, we fit a negative binomial multilevel growth curve model of weekly rates of unplanned

TABLE 2 Rates of Unplanned Hospitalization Before and After Tube Placement

	N	Baseline		Subsequent		Risk Ratio (95% CI)
		Raw Mean (d per Child-wk)	Adjusted Mean, d per Child-wk (95% CI)	Raw Mean (d per Child-wk	Adjusted Mean, d per Child-wk (95% CI)	
Entire cohort	948	0.23	0.23 (0.17–0.31)	0.24	0.21 (0.17–0.27)	0.92 (0.57–1.48)
Antireflux procedure	404	0.27	0.26 (0.18–0.38)	0.27	0.26 (0.18–0.37)	0.98 (0.51–1.9)
No antireflux procedure	544	0.20	0.21 (0.15–0.31)	0.21	0.19 (0.14–0.26)	0.88 (0.46–1.68)
Progressive NI[a]	156	0.27	0.29 (0.18–0.48)	0.33	0.37 (0.2–0.71)	1.27 (0.44–3.63)
Nonprogressive NI	792	0.22	0.23 (0.17–0.31)	0.22	0.2 (0.15–0.26)	0.86 (0.53–1.38)
Inpatient tube	279	0.36	0.42 (0.3–0.58)	0.39	0.33 (0.24–0.47)	0.8 (0.44–1.44)
Outpatient tube	669	0.18	0.16 (0.11–0.23)	0.17	0.17 (0.12–0.25)	1.1 (0.55–2.2)
Under age 4	468	0.29	0.29 (0.22–0.38)	0.28	0.29 (0.21–0.39)	0.99 (0.6–1.65)
Age ≥4[a]	480	0.18	0.21 (0.15–0.29)	0.19	0.19 (0.13–0.29)	0.92 (0.48–1.76)

Adjusted means and risk ratios were calculated with a negative binomial GEE adjusting for time and age.

[a] The variance function did not converge with alternate covariance structures, so independence was assumed. Mean estimates were unaffected.

TABLE 3 Association of Subgroup Membership With Rates of Weekly Unplanned Hospital Days

Subgroup	RR (95% CI)	*P*
Children over versus under age 4	2 (1.4–2.8)	<.001
Children with versus without progressive NI	2.4 (1.5–3.8)	<.001
Children with versus without antireflux procedure	1.3 (0.9–1.8)	.2
Children with versus without inpatient feeding tube placement	3.4 (2.4–4.9)	<.001

hospital days per child during the subsequent interval. Being inpatient for tube placement had the strongest association, with an RR of 3.4 (95% CI: 2.4–4.9), compared with children who were outpatients (Table 3).

DISCUSSION

In this population-based study, we found that children with NI had relatively high mortality after primary feeding tube placement (12.6% in 2 years and 24.2% in 5 years). Rates of acute health care use were stable in the 2 years after tube placement, including among clinically relevant subgroups. However, weekly rates of unplanned hospital days after tube placement varied across some subgroups and were highest among children requiring preoperative hospital stays.

Although, anecdotally, tube placement may represent an inflection point in a child's clinical trajectory, we did not find a consistent pattern of change across the population; instead, rates of acute health care use were stable before and after tube placement. This finding is important to help families anticipate the effect of tube placement during decision-making conversations. Additionally, although mortality is high in this population, it is not suggested in the study that tube placement is the cause. Instead, it is likely that tube placement is a marker for more severe NI and medical fragility. The stability of acute health care use rates argues against causality, because if feeding tubes were the primary driver of

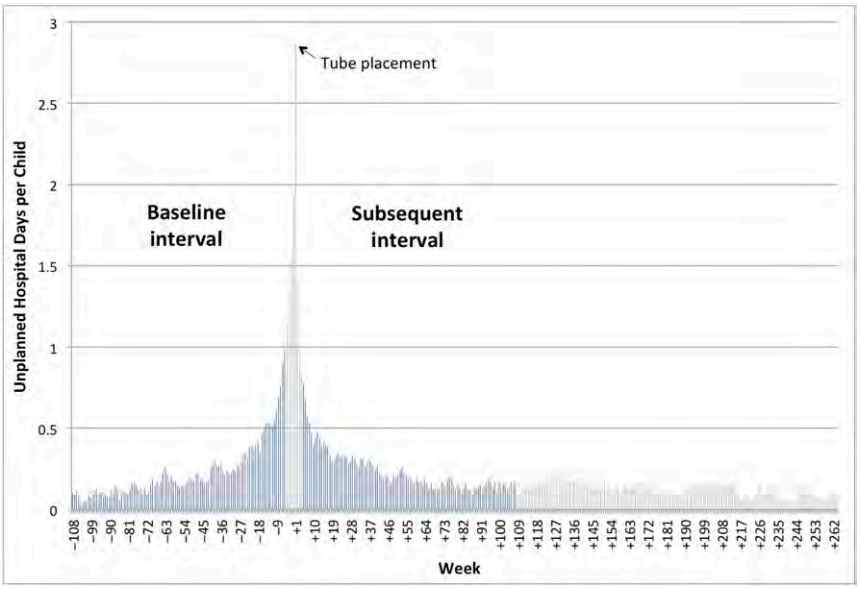

FIGURE 3
Bamboo plot for days of unplanned hospitalization per child for each week. The blue lines are used to indicate data included in the exposure-crossover analysis. The gray lines are used to indicate the induction interval and follow-up after the subsequent interval.

increased mortality, then postfeeding tube health care use would be expected to rise across the cohort.

Many of our findings are similar to previous studies. Authors of 2 single-center case series (n = 61 and n = 98) reported mortality rates of 17% and 21% during the 2 years after GT placement.[11,25] Most previous studies of health care use in this population are focused on reflux-related admissions, with mixed findings. Authors of 1 study (n = 57) reported decreased admissions after GT placement,[13] and authors of another study (n = 1142; 34% NI) found hospitalizations after antireflux surgery decreased for children ages <4 years but increased for older children.[24] Authors of a third study (n = 3721) reported no change in hospitalization rates after antireflux surgery.[18]

We leveraged large population-based linked data sets allowing robust outcome estimates with minimal loss to follow-up in our study. However, we had minimal clinical data on NI severity, which is likely associated with mortality and higher health care use. Although the consistency of findings in subgroup analyses testing markers for NI severity was reassuring, our inability to risk stratify is an important study limitation. Additionally, self-matching designs only control for time-independent confounders. The most important potential confounder in this study is change in underlying health status, but health administrative data lack the clinical granularity necessary to identify a changing baseline. Also, Ontario does not have a specific procedure code for advancement of a GT into the jejunum, so our finding that 5.3% of children received subsequent antireflux surgery over 5 years is likely an underestimate. Additionally, our cohort had higher rates of primary antireflux procedures (43%; predominantly GJTs) compared with a recent American study (18%; predominantly fundoplication),[5] which is important for study generalizability. The data in Table 1 suggest that the frequency of antireflux procedures in Ontario has changed over time, which is worthy of evaluation in future studies. Also, we cannot describe local variations in practice that might affect patterns of use. Finally, the data only include health care use within Ontario; care received outside the province is not captured. However, except for emergency care while abroad and rare cases of individuals traveling to receive care, we would expect that these data encompass most health care use for the cohort.

CONCLUSIONS

Mortality was common after feeding tube placement, occurring among 22.9% of children with NI over 5 years. Rates of acute health care use across settings and for clinically relevant subgroups were stable. However, given these findings and the variation in rates of unplanned hospital days after tube placement between subgroups, with this study, we underscore the need for further research used to inform risk stratification and prognostic accuracy in this population.

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ABBREVIATIONS

CCC: complex chronic condition
CI: confidence interval
GEE: generalized estimating equation
GJT: gastrojejunostomy tube
GT: gastrostomy tube
ICES: Institute for Clinical Evaluative Sciences
IQR: interquartile range
LOS: length of stay
NI: neurologic impairment
RR: rate ratio

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